

State Of California Drinking Water Program Water Treatment Operator Certification

EXPECTED RANGE OF KNOWLEDGE

GRADE 1

Grade 1 applicants are not expected to have a complete mastery of all subjects listed below, but at least should have heard of them in the context of water quality and treatment. Ability in basic arithmetic and an understanding of basic conversions is expected.

Water Treatment Mathematics

Working familiarity with:

- Calculation of dosage, feed rates, and flow rates
- Formulas (area and volume)
- Units and conversion factors
- Water measurements (metering)

Sources of Supply

- Chemical, physical, and bacteriological characteristics; variability
- Groundwater and surface water supplies
- Hydrologic cycle
- Reporting and approval requirements
- Safeguards in well location and construction
- Sanitary hazards for each type of water supply

Disinfection

- Purpose of disinfection
- Disinfectant types
- Characteristics of chlorine and chlorine compounds (gas/liquid)
- Available chlorine in various compounds
- Chlorine demand -- significance, variability
- Residual measurement methods, reagents used, and interferences
- Chlorine storage, feeding, and measurements
- Detection of leaks
- Hazards and safety requirements
- Characteristics of fusible plugs in chlorine containers

Elementary Water Chemistry

- Elements, compounds, alkalinity, hardness, pH; significance of changes in pH and alkalinity

Water Quality Parameters

- Microbiological, inorganic, organic, radiological, general mineral, and general physical

Microbiological and Chemical Quality

- Bacteria, viruses, and protozoan
- Coliform group -- occurrence, significance
- Oxygen starvation (methemoglobinemia) in infants
- Potential waterborne diseases
- Sampling requirements -- sample siting plan, sample collection, and reporting requirements

System Operation

- Distribution pipe system -- materials, sanitary hazards including cross-connection
- protection, detection, disinfection of new or repaired mains, operation and maintenance, sampling
- Metering pump calibrations
- Pumps and water pressure -- pump characteristics, positive displacement vs. centrifugal, sanitary hazards, calculation of pump output
- Static head -- meaning, significance
- Water storage facilities -- source and finished, purposes, operation and maintenance methods, and reliability

Regulations

California Safe Drinking Water Act and Related Laws book (Blue Book) is available on our web site: www.dhs.ca.gov/ps/ddwem/index.htm

GRADE 2

Grade 2 applicants are expected to be familiar with all subjects listed under Grade 1. they are not expected to have complete mastery of all subjects listed below, but at least should have some familiarity of them in the context of water quality and treatment. Ability to make common water works measurements, calculations, and conversion is expected.

General

- Per capita water consumption
- Reporting of complaints or illness -- to whom, how, when
- Water shortages and outages -- public health significance

Groundwater Supplies

- Confined/unconfined aquifer
- Geological formations -- effects on quality
- Types of wellhead treatment

Surface Water Supply

- Physical, chemical, and biological characteristics
- Stratification -- effects on treatment and water quality
- Treatment requirements/alternatives
- Watershed management

Distribution Systems

- Cavitation in pumps -- causes, effects, elimination
- Corrosion -- causes, effects, and control
- Cross-connections -- control program
- Distribution system -- maps, records
- Head loss in pipes -- causes, significance
- Main flushing
- Requirements for system air valves

Microbiological Quality Control

- Handling of bacteriological samples; dechlorination
- Methods of measuring microbiological quality
- Waterborne diseases -- pathogens; meaning and significance

Basic Chemistry -- Fundamentals of Matter

- Acids, bases, alkalinity
- Anions, cations, undissociated compounds
- Atoms, molecules, elements, compounds

Basic Chemistry -- Fundamentals of Matter (continued)

- Chemical properties of standard disinfectants
- Gases, liquids, solids
- Inorganic, organic compounds
- Solution, concentration, precipitation

Disinfection

- Breakpoint chlorination -- meaning, significance, determination
- Chlorine and activated carbon -- order of feed
- Comparative disinfection of clear water, turbid water, sewage
- Effects of heat applied to chlorine cylinder
- Effects of moisture on chlorine gas
- Effects of pH and temperature
- Feed rate as effected by temperature, cylinder volume, cylinder position
- Free vs. combined chlorine; chloramines
- Gas vs. liquid; application, methods
- Prechlorination -- meaning and significance
- Protection against inhalation of chlorine gas
- Relative effects on bacteria, viruses, cysts
- TTHM formation

Coagulation, Flocculation, Sedimentation

- Calculation of coagulant dosage rates
- Common coagulants; coagulant aids
- Complete treatment -- definition, requirements for contaminated water sources
- Dry and solution chemical feeders -- care and maintenance
- Effects of time and temperature in flocculation, coagulation, settling
- Effects of turbidity, alkalinity, pH on various coagulants
- Jar tests
- Suspended matter; colloidal particles
- Turbidity and color -- measurement, units, natural ranges

Filtration

- Backwash -- purpose, characteristics, hazards, rates
- Calculations -- filtration rates, backwash rates
- Diatomaceous earth -- characteristics, use, pre-coat, body feed
- Dual media -- meaning, advantages
- Filter media -- types, uses, uniformity coefficient, effective size
- Loss of head -- meaning, significance, measurement
- Rapid vs. slow sand filtration
- Underdrain systems -- functions, characteristics, hazards

Miscellaneous Treatment

- Activated carbon
- Advanced oxidation process
- Effects of pH on calcium/potassium/magnesium carbonate formation
- Fluoride application, removal, MCL
- Ion exchange -- synthetic resins, zeolite, effects, regeneration
- Iron and manganese removal; sequestering
- Multibarrier treatment
- Nitrate removal
- Optimum softening limits -- effects to household and pipelines; discharge requirements
- Softening chemicals -- effects of each
- Taste and odor -- cause, effect, removal
- TDS or total solids -- meaning, significance, reduction methods

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GRADE 3

Grade 3 applicants are expected to have a mastery of all subjects listed under Grades 1 and 2, and a familiarity with subjects listed under Grade 3. Ability to make a wide range of water treatment calculations is expected.

System Operation

- Cathodic protection -- uses, methods
- Cross-connection prevention -- devices, maintenance
- Factors influencing velocity of flow in aquifer
- Foaming -- in water supply, in treatment, in mains
- Incrustation and corrosion -- Langelier Index
- Master metering, characteristics of flow meters
- Nitrification -- symptoms and causes
- Separation of sewers and water mains
- Specific capacity of wells
- System losses
- Types of growth in water mains -- iron, sulfur, and nitrifying bacteria

Microbiological Quality -- Disinfection

- Anaerobic/aerobic/facultative organisms
- Biological effects of chlorine on microorganisms
- Chlorine: ammonia ratio
- Chlorine dioxide -- nature, uses
- Chlorine species in aqueous solution
- Disinfection of mains using chlorine tablets
- DPD/LCV test; amperometric test
- Drop-dilution methods for chlorine residual testing
- Fecal coliform test -- significance
- Meaning and calculation of presence/absence
- Operating capacity of various chlorine containers
- Plankton counts, seasonal variations, filter clogging organisms
- Prevalence of coliform bacteria -- significance
- Standard Methods for the examination of water and wastewater

Coagulation, Flocculation, Sedimentation, Filtration

- Alum and quicklime use, storage, and hazards
- Backwash rates
- Carbon dioxide/carbon monoxide relationship; hazards

- Complete treatment
- Detection of short-circuits in sedimentation basins; tracer studies
- Filter inspections
- Filter media uniformity coefficient, effective size
- Hardness and alkalinity
- Microstrainers
- Molecular characteristics of polyelectrolytes; uses
- Molecular transformation in the coagulation process
- Occurrence of hydroxide alkalinity
- Oxidation and reduction of iron compounds
- Pressure sand filter characteristics
- Requirements for backwashing
- Sand expansion
- Sedimentation basin overflow rates -- units, calculations
- Sludge -- characteristics, handling, disposal
- Surface wash, mudballs, air binding, bumping

Miscellaneous Treatment

- Activated carbon -- process, storage, safety, recovery
- Aeration in lime softening
- Air stripping
- Blending
- Treatment with copper sulfate
- Carbonate vs. non-carbonate hardness; removal differences
- Desalinization
- Effects on water quality of lime-soda softening, zeolite softening, of anion/cation softening
- Fluoride compounds -- characteristics, available fluoride
- Langelier Stability Index
- Recarbonation -- purpose, methods
- Reverse osmosis
- Upflow and solids contact clarifiers

Regulation

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GRADE 4

Grade 4 applicants are expected to have a mastery of all subjects listed under Grades 1, 2, 3, and 4 plus a practical familiarity with treatment plant design, water utility management, safety, and public health. Ability to make a wide range of water utility calculations is expected.

From Watershed to Customer Tap

- Activated silica vs. polymers
- Air binding -- causes, effects, elimination
- Application of anionic, cationic, and nonionic polymers
- Bridging -- causes, effects, elimination
- Brilliant green bile test -- significance
- Calculation of CT values
- Calculation of optimum coagulant dosage
- Chemical dusts and fumes vs. electrical equipment
- Compound-loop chlorinator controls
- Corrosion studies
- Density currents in sedimentation basins
- Destruction of chloramines; dosages required
- Diatomaceous earth filters -- pre-coat rates and depths, body coat rates and depths
- Emergency response plans and program
- Excess lime softening -- purpose, dosages, quantities
- Foot valves and check valves in pump installation
- Gravimetric vs. volumetric feeders
- Hydraulic factors, e.g., Hazen-Williams C
- Ion exchange brines -- characteristics, disposal
- Iron salts vs. aluminum sulfate
- Lateral sand migration during backwash
- Membrane filtration
- Nitrification -- significance and solutions
- Overflow weir; significance of length
- Pipe materials -- in corrosive soils/water
- Plant and remote instrumentation; telemetry control methods
- Reaction chemistry and quantities in coagulation and softening
- Removal and or inactivation of microbes
- Required flow capacity from source
- Safety regulations
- Sedimentation basin tube settlers
- Significance of aesthetic quality standards
- Solubility of oxygen; effect of temperature
- Surface cracking in filter beds
- Temperature effects on sedimentation
- Zeta potential -- meaning, calculation

GRADE 5

The Grade 5 exam is an oral exam. You have 20 minutes to show the panel that you have the ability to administer a water treatment plant of any size and type, anywhere in California.

All Grade 5 candidates, and the interview panel, will be given the following information. The panel will use these guidelines in developing their exam questions.

- During the oral exam it is assumed that you are the chief administrator of a given water treatment plant or the entire utility
- Your plant or utility uses both groundwater and surface water
- This source water has all known quality problems
- You have available for your use all known technology to solve these water quality problems
- You must deal with all the staff in your utility
- You must deal with the public
- You must deal with the press
- You must deal with the regulators - federal, state, county, and local
- You must have a complete understanding of all current and pending regulations pertinent to a water treatment plant
- You must be aware of current water industry issues. These issues would be feature articles (found on the cover) in the American Water Works Association "Journal" for the year prior to the exam
- You must know how to handle any emergency situation pertinent to your water treatment plant
- Remember that this is a "Health Department" administered certificate
- Remember that you will be asked to solve problems using your wit and not a screwdriver
- Keep in mind that since you are the chief administrator of your company, your answers should try to incorporate the viewpoint of the Health Department in attempting to safeguard the public health. Look for the broader picture of ensuring your operation is safe and what you do is in the best interest of the public

SUGGESTED READING

CALIFORNIA SAFE DRINKING WATER ACT AND RELATED LAWS ARE AVAILABLE FROM THE COUNTY COURTHOUSE OR PUBLIC LIBRARIES; ALSO BY WRITTEN REQUEST TO THE DIVISION OF DRINKING WATER AND ENVIRONMENTAL MANAGEMENT. CALL (916) 323-6111 FOR COST.

California Health and Safety Code & California Code of Regulations

California Safe Drinking Water Act and Related Laws book (Blue Book) is available on our web site: www.dhs.ca.gov/ps/ddwem/index.htm

Correspondence Courses

**Kenneth D. Kerri
Office of Water Programs
California State University, Sacramento
6000 J Street
Sacramento, CA 95819-6025
(916) 278-6142**

- Water Treatment Plant Operations, Volume 1* (#)
- Water Treatment Plant Operations, Volume 2** (#)
- Small Water System Operation & Maintenance
(Suggested reading for Grade 1 only, not for education credit)

References

**New York State Department of Health
Health Education Service
P.O. Box 7283
Albany, NY 12224**

- Manual of Instruction for Water Treatment Plant Operators

References (continued)

**American Water Works Association
Customer Service Department
6666 West Quincy Avenue
Denver, CO 80235
1-(800)-926-7337**

- Water Treatment*
- Basic Science Concepts and Applications
- Introduction to Water Sources and Transmission
- Introduction to Water Quality Analyses**
- Water Quality and Treatment***
- Operator Certification Study Guide (#)
- AWWA Standards
 - Disinfection of Water Treatment Plants
 - Disinfecting Water Mains

**Joanne Kirkpatrick Price
Technomic Publishers
1-(800)-233-9936**

- Basic Math Concepts for Water and Wastewater Plant Operations, 1991 (#)

**College of the Canyons Bookstore
(805) 259-4224**

- Mathematics for Treatment Plant and Water Distribution Operators, 1995
(Gates, Froelich, Pecs) (#)

**Wright's Training (Grover Wright)
P.O. Box 515
Elmira, CA 95625-0515
(707) 448-3659**

- Math Text for Water and Wastewater Technology, Second Edition 1994
- Sample Water Treatment Plant Operations Questions (#)

- * Appropriate for Grades 1, 2, 3, and 4
- ** Appropriate for Grades 2, 3, and 4
- *** Appropriate for Grades 3 and 4
- (#) Contain Sample Exam Questions